1984

2710444
2780139
6640205
6080058
PD-AAP-932
ISN 36536

SUMMARY EVALUATION:
FOUR WHEAT PRODUCTION PROJECTS IN FOUR NEAR EAST AND NORTH AFRICA COUNTRIES

BY

DR. EDWARD B. HOGAN

CONSULTANT NE/TECH/AD

WITH AN APPENDIX BY

DR. WILLIAM FURTICK

CONSULTANT NE/TECH/AD

Views and interpretations expressed in this report are those of the author and should not be attributed to the Agency for International Development

000133
S

TABLE OF CONTENTS

PAGE

EXECUTIVE SUMMARY.....1

I BACKGROUND.....1

II SETTING.....2

III DESCRIPTION.....5

IV IMPACT: FINDINGS.....8

V IMPACT: ANALYSIS.....14

VI CONCLUSIONS AND LESSONS LEARNED.....22

STATE OF ART OF NEW TECNOLOGICAL INNOVATIONS UNDER DEVELOPMENT FOR DRYLAND AREAS WITH EMPHASIS ON CEREALS, BY DR. WILIAM FURTICK.....Appendix

I. BACKGROUND

During the second half of the 1960's AID undertook four projects in the Middle East and North Africa to increase wheat production. These projects were:Turkey, Cereals Production; Jordan, Wheat Research and Production; Morocco, Increase In Cereals Production; and Tunisia, Accelerated Cereals Production. Other participants in wheat production activities with AID as donors or contractors included Oregon State University as contractor in Turkey and Jordan, CIMMYT as contractor in Tunisia, Turkey and Morocco, Near East Foundation as contractor in Morocco, Rockefeller Foundation as donor in Turkey and Ford Foundation as donor in Tunisia. The period of implementation for the projects varied widely. In Turkey AID and Rockefeller financing extended from 1967 to 1982. The Morocco project started in 1968 and ran to 1974; the Tunisia project covered the period 1965 to 1976; while the Jordan project started in 1968 and ended in 1975 with a three year interuption in implementation about half way through the project.

AID has undertaken Impact Evaluations of three of the projects; the Tunisia evaluation study was conducted in April 1982 and those for Jordan and Morocco in October, 1983. The Rockefeller Foundation has in preparation a review of wheat improvement activities on the Turkish Anatolia Plain from 1969 through 1982 based, in part, on an evaluaation meeting held in Ankara to review the project. On November 22 and 23, 1983, AID sponsored a workshop to review and assess experience in dryland wheat production programs in the Middle East and North Africa with particular emphasis on the Turkey experience. This report is derived largely from the findings of the three AID Impact Evaluations, the Rockefeller study, which was kindly made available to the author in final draft form, and materials presented at the two day workshop.

Before proceeding to the major portion of the report, one point needs to be made. The AID wheat project in Turkey consisted of two separate stages. The first stage consisted of the introduction of high yielding varieties of spring wheat developed by CIMMYT into the high rainfall coastal zone of Turkey. The second stage was directed towards increasing yields of winter wheat in part of the dryland interior of Turkey largely by the introduction of improved cultural practices. This review is focused on the second, not the first, stage of wheat production activities in Turkey.

II. SETTING

During the 1960's each of the four countries were faced with a similar problem. The major cereal produced for human consumption was wheat and production was failing to keep pace with increased consumption largely associated with population growth and urbanization. This meant increasing reliance on imported wheat, particularly for urban consumption, with consequent unfavorable effects on the balance of payments. While by no means precisely the same, there were many similarities in the kinds of constraints limiting wheat production in the four countries. One difference which should be noted was that in Morocco and Tunisia one constraint on production was related to the departure following independence of European farmers operating relatively large efficient farms on the best agricultural land. This circumstance did not exist either in Jordan or Turkey. A second difference was that during the period of project implementation, there was reasonable political and security stability in Morocco and Tunisia, while in Turkey govenments changed frequently and in Jordan agricultural development activities were interrupted by Arab-Israeli conflicts. A third difference was the priority assigned by governments to increasing wheat production. In Turkey, increasing wheat production substantially was clearly an high priority within the agriculture sector. By contrast, in Jordan and Morocco, increasing dryland wheat production had a priority clearly below that assigned to irrigated agriculture. In these countries investment allocations went largely to irrigated agriculture and essential human resources were not made available for support of wheat production. In Tunisia, achievement of food, including cereal, self-sufficiency was a clearly enunciated policy of the government and both human and capital resources were made available to the wheat project.

The most important similarity among the countries was that wheat production was carried out mostly as dryland farming dependent for moisture on winter rainfall. Characteristically, rainfall in the wheat growing areas ranged from 200 to 600mm with rainfall approaching 600mm largely limited to parts of northern Tunisian and the Anatolian Plain in Turkey. Moisture was the an important limiting factor affecting wheat yields and in many areas a wheat crop could be grown only every second year. Often in places where rainfall might otherwise have been considered quite adequate for annual wheat production such factors as shallow or rocky soils, clayey soils or temperature extremes reduced the capacity of the soil to retain moisture through the growing season. Rainfall in the dryland wheat growing areas was characterized by large variations from the normal. Both variations in the distribution of rain throughout the growing season and variations from the normal quantity of rain occurred with frequency. It was not unusual in some areas

for rainfall to be well below normal in two years out of five. In addition the variability in annual rainfall is greater in low rainfall zones than in high rainfall areas.

The level and variability of rainfall in these dryland wheat producing areas were the major factors which led to the development of cultural practices that minimized risk and provided for family security even in the years of poorest rainfall. The system developed over the millenia wheat has been grown in these areas was structured to minimize losses during periods of scarce rainfall and assure the availability of feed for livestock. These management practices also meant that yield was not optimized during periods of normal or better rainfall and that moisture was not adequately conserved for cereal plant growth. Over a very long period of time this system of cultivation for providing food security to farm families was not improved upon, except for some replacement of animal power by tractor power. There are few examples of successful efforts to increase production in these dryland areas.

Another characteristic common to these countries was the lack of institutional capacity to undertake research on improving wheat yields or to utilize research results from other countries or the international research institutions. Trained scientists capable of carrying out necessary agronomic, breeding, economic, pathologic, etc. studies necessary to develop and test improved ways of doing things were in very short supply and most of them were assigned to tasks other than increasing wheat output. Neither were there adequately financed research institutions, within or outside the Ministries of Agriculture, which could organize the necessary research programs. Similarly, there were neither public nor private services which were capable of furnishing research results to farmers if they became available. The institutional support necessary for agriculture development functioned at too low a level to be effective as far as wheat production was concerned.

At the same time that the four countries were experiencing increasing shortages in wheat production, developments outside of the area were increasing expectations that cereal yields could be substantially improved. Most importantly, international research institutions financed by the Rockefeller and Ford Foundations had made breakthroughs in producing high yielding wheat and rice varieties. These high yielding varieties were beginning to show highly positive results in the Far East and Southeast Asia. Dr. Norman Borlaug was soon to receive a Noble Prize for his contribution to these scientific achievements. For those working at the frontiers of agricultural development, spreading the "Green Revolution" looked like the way of the future. Not all progress in yield increasing wheat technology was being made at the international

research institutions. In particular, university scientists in the U.S. Pacific Northwest had made significant progress in developing moisture conservation techniques for dryland cereal farming, building on summer fallow systems developed through trial and error by farmers in the area.

It was a convergence of these events which led to the undertaking of projects to increase wheat production in four North Africa and Middle East countries. While the countries were no longer able to satisfy an ever increasing demand for wheat from domestic production, the means to do so appeared to be at hand as a result of scientific advances in the development of high yielding cultivars and improved crop husbandry. At the same time, AID and other donors were prepared to help the countries experiencing increasing cereal deficiencies to develop and expand their capability to use modern scientific technology to achieve food security and free scarce foreign exchange resources for development purposes. The major objectives of these projects were related to increasing the productivity of the agriculture sector and the total economy. The cereals farmer was the instrument through which these increases were to be brought about. However, which groups or individuals largely benefitted from these activities was not a matter of explicit concern in the development of these projects.

III Description

These four wheat projects in Jordan, Turkey, Morocco and Tunisia were prepared and approved prior to the adoption by AID of a project preparation system that included a logical framework specifying inputs, outputs, purposes and goals. Never-the-less, it is possible to reach reasonable conclusions about what these were from the perspective of nearly two decades later. The purpose of each project was to increase wheat production substantially. In Turkey and Tunisia this was identified as achieving self-sufficiency in wheat production within a specific time period. In Morocco, wheat production was to be increased by fifty percent in less than a decade and, in Jordan, output was to be doubled in about a dozen years. Achievement of these purposes would help the countries achieve the goal of conserving foreign exchange. In each country the inputs were to be largely high yielding varieties of wheat and/or improved cultural practices provided by technical assistance and the outputs increased yields. The projects were straight forward, uncomplicated activities to remove or diminish constraints on resources which limited the potential for supply to respond to increased demand.

For each project increased yields and total output were to be achieved by technical assistance which introduced and tried, initially on a limited trial/demonstration basis, technologies developed and utilized outside of North Africa or the Middle East. In all projects the emphasis at the project preparation stage was on the transfer of technology to recipient countries to increase output rather than on developing the institutional capability within the country to carry out, on a continuing basis, necessary research, extension and input supply. However, within a short period of time, not more than a year after the start of implementation, institution building, as an esential component of a sustainable production increasing activity, began to be incorporated into three of the projects. In the fourth project, in Jordon, the necessity for developing institutional capability was recognized by implementing agency technicians and included as a component about half-way through the project.

The wheat yield increasing technology proposed for introduction was not the same in all four countries. In two countries, Tunisia and Morocco, the major focus was on the utilization of high yielding variety seeds with associated recommended practices. Cultural practices were not ignored but a package of practices focusing on moisture conservation was not a central part of the project. Contrariwise, the projects in Turkey and Jordan put moisture conserving cultural practices front and center. The possible benefits from introducing high yielding varieties was not ignored. However, in both countries, the position taken was that existing cultural practices fell far short of achieving optimum yields with

seed varieties currently in use and only after the adoption of moisture improving technology resulted in achieving desirable yields from existing varieties should high yielding varieties be introduced. The source of technical assistance varied in the same way that choice of technology varied. In Jordan and Turkey the major source of technical assistance was Oregon State University, while CIMMYT was the main source of technical assistance in Morocco and Tunisia where the emphasis was on the introduction of high yielding varieties.

There were substantial differences in the results of the four projects. Production increases initially projected were achieved only by one country, Turkey. In Tunisia self-sufficiency in wheat production was not achieved, though there have been substantial increases in output since the initiation of the project in 1968. In this respect it should be noted that AID's emphasis on self-suficiency shifted gradually to economically sound self-sufficiency and institution building. Later this was modified to producing 875,000 metric tons of wheat per year and developing an indigenous cereals production program. This production target was achieved though its composition differed somewhat from that planned. In neither Jordon nor Morocco did production achievements approach the targets set for the projects. Any yield increases achieved as a result of the projects were, for the most part, offset by other factors affecting total wheat output negatively.

As noted above, institution building became an important element in the structure of three of the four projects. In the two countries where substantial production increases were achieved institution building was reasonably successful. Institutions were established and strengthened, including training of necessary scientific staff and became going concerns capable of conducting ongoing research and disseminating information to farmers. In Morocco attempts at institution building were unsuccessful in establishing either research or extension organizations with the capacity to carry on continuing development, maintenance and dissemination of improved wheat varieties. In Jordan, as indicated earlier, institutional development never really got underway and recommendations made for a follow-on project high-lighted the need for institution building. In the Morocco case, it should be noted that, despite the failure of institutionalization efforts, some useful breeding work was carried out on a continuing basis by an expatriate employee of the Ministry of Agriculture.

Another important difference among the projects was the implementation time period. In Turkey the donors continued assistance for nearly a decade and a half, while in Tunisia direct assistance lasted a little over a full decade. By contrast, in Jordan actual implementation of the wheat project

was carred out for only four years over a seven year period and with a very small staff. In Morocco, the life of project was only seven years; attempts at institution building ended after five years with the withdrawal of CIMMYT from the project.

Finally, the different kinds of technology transferred to Tunisia and Morocco on the one hand and Turkey and Jordan on the other affected the magnitude and timing of planned production increases differently. All four countries produced soft bread wheat and hard durum wheat. The percentage of durum wheat produced ranged from about forty percent in Turkey to seventy-five percent in Morocco and Tunisia. During the time period in which the four wheat projects were being started high yielding varieties had been developed at CIMMYT only for bread wheat. This meant that in Tunisia and Morocco twenty-five percent or less of the crop would be affected by the utilization of existing high yielding varieties imported under the project. However, in the Anatolian Plateau of Turkey and in Jordan, the technologies imported for testing and adaptation were equally applicable to durum and bread wheat and could favorably affect all wheat production. In Tunisia research on improved durum wheat varieties started early on, by the 1969/70 crop year, and new durum varieties made available to farmers in 1979 played a major role in bringing about the very large increases in yields and output of wheat during 1980 to 1982. In Morocco some progress was made in developing high yielding durum varieties but, as yet, they have not had a major impact on wheat yields or output.

IV IMPACT: FINDINGS

A. Introduction.

The four projects all achieved some measure of success even though the effect on output was clearly positive in only two countries while little or no clearly discernable increase in total output occurred in the other two countries. The available evidence does not permit any conclusions to be drawn about the effect of the projects on yields in the latter two countries, Jordan and Morocco. There are some reasons to think that the technologies introduced may have brought about some limited yield increases. The amount of land area allocated to wheat production in both countries has declined as a result of urbanization and changes in cropping patterns and, at least in Morocco, total average production over a five year period seems to have increased marginally. In Jordan, the situation is more murky, particularly because of the frequency of drought in recent years; but yields do appear to have, at least, been maintained even though it has been the better lands which have been taken out of wheat production.

B. Project Components.

The structure of the projects in all four countries was similar in some major respects but not in others. Most importantly all of the projects were focused on wheat production and excluded involvement with other crops or livestock. Increased production was to be brought about by the introduction of technologies new to the country's agriculture. The projects were all products of a firm belief in the efficacy of improved technology as the engine driving increases in yield of cereal crops. This belief was rooted in the experiences with the "Green Revolution" in Asian countries.

The projects were also similar in that none of them originally included provisions either for economic/social analysis or the development of host country capability to deal with economic or social issues related to dryland wheat farming. Project objectives in all four projects were formed solely in terms of quatitative targets beneficial to the economy as a whole. Countries were to become self-sufficient in production, double production and/or reduce a drain on the balance of payments. The beneficiaries were to be the country as a whole.The consequences for individuals, whether producers or consumers, were not dealt with in developing the projects. A major assumption was that the technologies were cost effective either as parts of the package or the total package as a whole, yet this critical assumption was never precisely tested or quantified.

There were at least three major differences among the projects. First, the technology to be transferred was not the same in all four countries. In two countries, Turkey and Jordon the primary technological change was the introduction of

improved tillage directed to conseving moisture in order to maximize production from available plant material. The potential role of high yielding varieties was not ignored, and, particularly in Turkey, work was initiated to develop institutional capability inplant breeding. However, production objectives were to be achieved largely through realization of the production potential of existing varieties by improving cultural practices. In the other two countries the primary emphasis was placed on the introduction of new high yielding varieties and certainly did not include utilization of moisture conserving technologies.

Second, there were important differences in the length of time during which external assistance was supplied. In both the Tunisia and Turkey projects technical assistance including institution building and training contiued for over a decade while in the other two countries these activities were terminated earlier. In Jordan the period of assistance was limited to five years and, as noted above, the technical assistance staff was quite small. In Morocco the project was continued for seven years but tecnical assistance to research encountered difficult implementation problems which severely limited technology transfer and institution building.

Third, much greater emphasis was put on institution building in two countries than in the other two. Institutional development was a major component of the Turkey and Tunisia projects. Importantly, in both countries a major effort was undertaken to train the scientists necessary for proper staffing of research organizations. In Jordan institutional development never really got started and in Morocco the government never accepted the importance of developing institutional capability.

C. Government Policies.

There was considerable variatain among the four countries with respect to policies affecting wheat production. In Morocco and Jordon agricultural development policies gave first priority in resource allocation to irrigation schemes. In Jordan this resulted in the transfer of highly qualified agricultural staff out of dryland agriculture and in Morocco the unwillingness of Moroccan officials to provide staff necessary to develop research and extension institutions focusing on cereals production was in part due to the higher priority assigned to irrigation activities. In Turkey and Tunisia increasing domestic, dryland wheat production was accorded a high priority in agricultural development plans.

In only one aspect was price policy similar in all four countries. As is common throughout the Middle East and North Africa the consumer price for bread or wheat flour was subsidized. In fact, in two of the four countries the consumer price was so heavily subsidized in later years that farmers increased their income by selling wheat and buying bread or

wheat flour.

Producer price policies differed among the four countries but tended to become more similar over time. In Tunisia prices paid for wheat have been generally lower than international prices, though after 1973, price increases have brought prices paid to farmers much closer to world prices. In Morocco, by contrast, prices for cereals have been consistently above world price levels since the 1950s and in recent years fifty percent or more above. In Turkey prices paid to farmers were generally favorable. Finally, in Jordon until 1979, farm gate prices were well below border prices. But, starting in 1979, prices were increased substantially and are now consistently well above world prices. It should be noted that in both Morocco and Jordon the amount of wheat bought at official prices is only a small proportion of wheat bought for the large commercial milling operations. Costs to government of heavy consumer price subsidies are minimized by relying in a major way on relatively cheap imported wheat to supply urban consumption.

Government policies among the four countries varied with respect to input pricing, though in each country there was some form of agricultural input subsidy. In Tunisia government apparently tried to offset its consumer pricing policy for cereals by holding down the price paid to producers. The government, in turn, tried to encourage the use of improved inputs through a subsidy program for fertilizer, improved seed, insecticides and credit. In Morocco, the policy on subsidies was to a large extent unclear. High yielding seed varieties were subsidized to encourage their use. Other inputs were subsidized but often to groups rather than individuals. In many cases subsidies and duties or taxes were imposed on the same inputs and more or less offset each other. In Turkey, there was usually some form of subsidy to encourage the use of improved inputs. In Jordan, the major reliance was on tax exemptions rather than on subsidies. For example, farm machinery was exempt from all duties and taxes, though spare parts did carry rather heavy import duties. Jordan did provide some subsidies for fertilizer and credit but largely relied on market prices in an active private sector.

D. Risk.

It is generally recognized that the risks associated with drylands cereals production are high. Annual output of grain will fluctuate widely due to the variation in rainfall. Yield fluctuations are apt to be wider for the new high yielding varieties than for the more traditional varieties because of the greater reliance on fertilizer, the utilization of which is dependent on moisture. However, improved cultivation technologies can increase the amount of water available for plant growth.

The evidence from all four countries, although to some

degree fragmentary, shows a strong relationship between risk and willingness of farmers to adopt new technology and the way in which new technology is utilized. Among the four countries, the Turkey and Tunisia projects were located largely in areas with normal rainfall ranging from more than 300mm to over 600 mm. In Morocco and, particularly in Jordan, much of the area served by the projects normally received less than 350 mm of rain annually.

The available data, mostly from Jordan and Turkey, show that dryland wheat farmers almost never adopt a technological package as a whole. They also show the rate and kind of practices adopted varies with rainfall. For example, in Jordan a survey of adoption of new technologies by wheat farmers shows that those in areas receiving less than 250mm of rainfall none of the proposed package of practices was adopted and that in areas receiving between 250 and 300mm only the practice of using clean seeds was adopted. However, most farmers, sixty-seven percent, in this rainfall area did adopt the practice. In areas with more than 300 mm of rainfall farmers adopted some of 5 out of 6 of the components included in the improved technological package. The adoption rate for clean seeds was highest, nearly ninety percent, followed by herbicides and fertilizer. It is interesting to note that a study in Turkey showed the same pattern for adoption of new practices if one considers only those practices introduced which were common to both countries.

E. The Cereals/Livestock Relationship.

As is common with much of dryland agriculture throughout the world, farm operations in all four countries included utilization of the same land resources for both crop and livestock production. However, in none of the four projects was any attempt made to take the crop/animal symbiotic relationship into account in planning or carrying out project activities. One of the consequences of this was that such few attempts as were made to calculate cost/benefit ratios of introducing new technologies ignored returns from straw fed to livestock and, therefore, consistently underestimated revenues. As returns from straw are often from fifty to one hundred percent of the returns from grain, this was a serious error.

Farmers decisions with respect to wheat production are partially determined by the effect on animal production. For example, in Morocco the farm operation, particularly for smaller farms, is structured to maximize sheep production. Because of the importance of weeds as animal feed in the production strategy followed by many Moroccan dryland farmers, wheat production practices which reduce the availaility of weeds as feed may be viewed by the farmer as income reducing rather than income enhancing. Where hand weeding of wheat is a common practice, then weeds are often permitted to obtain

maximum growth short of flowering to obtain the greatest possible supply of animal feed. Similarly, when weedy fallow or the early spring growth of weeds forms an important element of the feeding cycle for animals, then clean fallow or early plowing may be perceived by the farmers to be against their best interests. While highly specialized operations of either wheat or forage production, or both, may, conceptually, yield optimal returns, specialized forage production was never fully developed.

Such evidence as is available indicates that the livestock/wheat relationship was important in all four countries. In Turkey, adoption of early plowing practices recommended appears to have been impeded by spring animal feed requirements. In Morocco, chemical control of weeds appears to be unpopular among some farmers because of its adverse effect on the availability of animal feed. In Jordan, one of the factors limiting adoption of clean fallow was the reluctance of farmers to eliminate a potential source of animal feed. For Tunisia, there is little direct evidence of problems encountered because of animal feeding requirements, though the evaluataion does note that attempts to introduce a rotation system incorporating forage crops rather than weedy fallow encountered problems because of animal feed requirements.

F. Social and Economic Change.

During the nearly two decades since the first of the four wheat production projects was initiated there have been many social and economic changes in the four countries which have had an influence on farm operations including dryland cereals production. The most important of these have been increasing urbanization, increasing alternate employment opportunities for rural families and changing patterns of land tenure.

1. Urbanization. In all four countries, continually increasing urbanization, which is associated with increasing non-agricultural employment, affected the demand for wheat in at least three ways. As people moved to the city and ceased to produce wheat the monetized demand for wheat grew, enlarging the market for wheat. At the same time demand also shifted from wheat to bread or wheat flour and from barley to wheat. Finally, it is probable that incomes of those moving to urban areas increased with a consequent income effect on the demand for wheat. All of these factors acted to increase the demand for wheat and raise the price of wheat. However, wheat was, (and is), the basic wage good and increasing non-agricultural production and employment partially depended on keeping the price of the wage good down. Governments faced a policy dilemma. Increasing production to meet consumer demand appeared to require higher wheat prices; but continued growth in the manufacturing, construction and service sectors would be facilitated by a low price for wheat. In this situation all four countries, as noted previously, resorted to some

combination of subsidized consumer prices, increased producer prices or input subsidies. All made some effort to utilize improved technology to increase production. Turkey accorded this effort high priority within its development plans and so did Tunisia, though probably to a lesser extent, at least in the earlier years. Unfortunately, the evidence indicates that less attention than was probably desirable was focused on the way in which improved technologies affected the costs of production.

2. Employment Opportunities. Though there were some difference in degree, alternate income opportunities for farm families increased in all four countries. Alternate job opportunities for farm family members consisted of farm labor on other farms, nonfarm employment within the country or employment abroad in European or other Middle East countries. The growth in job opportunities increased the opportunity cost of labor and reduced the contribution of farm income to family security. This led to an outflow of labor from the farm and to increased substitution of capital for labor in the production of cereals. It has also led farmers to consider alternate cropping systems which provide greater returns to labor. The opportunity to earn off farm income combined with a pricing structure of cheap bread or wheat flour and high incentive prices for wheat production means that on farm consumption of wheat becomes less attractive to farmers. 3. Land Tenure. There are two important aspects of land tenure which affected farm operating decisions. First, the ownership of land has been increasingly fragmented in accordance with the precepts of Moslem law. As land is divided into increasingly small parcels or held in common by a geometrically expanding number of people, returns to ownership and labor decline. With the increased off farm employment opportunities noted above, allocating labor to farming becomes progressively less attractive. Second, as land ownership has become increasingly fragmented and alternate employment opportunities increase, renting land has become more common. The typical pattern is one of owners of small parcels of land renting to large or medium size farm operators whose farms are mostly composed of rented land. Leases are usually short term, for one crop year, and can be rented either on a crop share or cash basis. Related to land rental and stemming from the same cause is the practice of having all or virtually all of the farm work performed by custom operators. Thus an owner or group of owners, usually from the same family, will contract with an owner of farm machinery to cultivate, spray and harvest the crop for a set fee.

V. IMPACT: ANALYSIS

A. Project Acomplishments.

While production objectives were reasonably achieved in only two countries, and then over considerably longer periods of time than originally planned, there were other benefits from the projects which were not unimportant. First, it needs to be emphasized that much of the success in increasing production in Turkey and Tunisia is attributable to development under the projects of the institutional capacity to continually maintain, distribute and improve technology. While evaluations of the wheat projects in the two countries did identify remaining institutional weaknesses, the institutions do function well enough to maintain and expand work undertaken by the projects. Without this capability it appears reasonably clear that the production successes would not have been achieved.

In the other two countries, if quantifiable, it is highly unlikely that investments in the two projects would show a positive internal rate of return. Never-the-less, there were certain positive results. In Jordan, the Oregon State University technicians and their Jordanian colleagues did satisfactorily demonstrate that improved moisture conserving technology could bring about substantial increases in output, at least in areas where rainfall exceeds 300 mm per annum. Subsequent economic analysis indicates that net returns to producers are positive though it is questionable if they represent the best production alternatives to farmers. In Morocco improved varieties introduced under the project continue to be important either as parent stock or as producing high yielding varieties. Work under the project did provide a basis for the eventual development of high yielding durum varieties. In addition, Morocco did establish a long term relationship with CIMMYT that has provided them with a continuing supply of improved variety materials.

Successful achievement of acceptable output increases was not related to the kind of technology transferred. Of the two countries where the predominate emphasis was on improved cultural practice, one country was successful in bringing about signifiant production increases and one was not; similarly, in the two countries where the major thrust was introduction of high yielding varieties, quite acceptable production increases were achieved in one country but not in the other. Clearly factors other than the type of technology introduced were the determinants of the degree of project success. For example there is no reason to believe that a project emphasizing cultural practices would have produced more successful results than the project featuring improved varieties that was implemented in Morocco. It is true that improved cultural practices are important to maximizing dryland wheat production in Morocco; but, given the other factors that have been shown

to have influenced project progress in Morocco, it is unlikely that the introduction of a different technology would have led to meaningful increases in production. However, given the necessary policy and institutional support, it is likely that a balanced project, including institution building, attention to the livestock/cereal crop relationship and improved moisture conserving technology would have produced results superior to those that could have been obtained from a project emphasizing only one of these elements. Appropriate technology is a necessary but not sufficient condition for bringing about production increases.

There was a positive association between yield increases and both the length of time external assistance was provided and the emphasis accorded institution building by the donors and the recipients. The importance of length of time in relation to output increases is demostrated by the length of time it took for substantial increases in output to occur in both Tunisia and Turkey. In Turkey yield increased by about.1 tons/hectare during the 1966-70 period and then increased geometrically over each of the next five year periods -- .2 tons/hectare during 1971-75 and .4 tons/hectare during 1976-80. Although the Tunisia project started in 1966, it was only after 1974 that wheat yields began to increase modestly and the largest yield increases occurred in the three years after 1979. In Morocco and Tunisia where projects were of a much shorter duration these types of yield increases never came about.

Similarly, both the Tunisia and Turkey programs put great emphasis on institution building, including the training of scientists. In both countries functioning research and extention organizations were developed with the capacity to carry out continuous work on improving and dispersing wheat production technologies. This does not mean that organizational, coordination and funding problems do not continue to exist. They do, but these institutions did develop the necessary competence to cope in an increasingly effective manner with production problems. By contrast, no such indigenous capability emerged from the projects in Jordan and Morocco. In Morocco termination of the project was brought about by government's inability to support institution building activities. While some breeding work continued no institutional capacity existed to maintain, improve or distribute a continuing stream of improved technology which might have brought about badly needed production increases. In Jordan the special unit established to work on wheat production with the AID financed technicians continued to work during a three year hiatus in the project; but, with the termination of the project, the unit was disbanded and their expertise was permanently lost to the country.

B. Policies

The evidence indicates that government policies were important determinants of project sucess. However, it is also apparent that the policy issues are quite complex. There are a variety of policies which affect efforts to increase wheat production and these policies are based on a complex mix of considerations much broader than any particular project.

Price policy affecting wheat production and the adoption of approved technologies includes both producer and consumer prices. Singly and in combination with each other these prices affect both production and market patterns. There appears to be little question that in at least two countries the combination of low consumer prices and relatively high producer prices produced some undesirable results. Farmers were able to increase their net revenue by selling wheat and buying flour or bread. The low consumer price led to other distortions. The amount demanded by consumers increased and was partially responsible in those countries for demand exceeding domestic supply. Thus, not only did the consumer subsidy constitute a drain on the Treasury but it adversely affected the balance of payments. Additionally, the low consumer price for wheat caused consumers to substitute wheat consumption for barley and reduced the demand for that product. This led farmers to substitute wheat production for barley production on land that was really marginal for wheat production because of low rainfall.

It is not possible to draw any firm conclusions on the role of price policy in the four countries. It is a mixed bag at best. About the most that can be said is that price policy by itself is not sufficient to bring about desired supply responses. This does not mean that incentive prices are not necessary, they are. The real issue centers around the price level required to provide the necessary incentive. In Morocco farm gate prices above world prices did not provide the necessary incentive, given the technology available. In Jordon increasing prices substantially above border prices has apparently had little or no effect on total production. However, in Tunisia farm gate price levels generally below world prices brought forth substantial increases in production, while in Turkey the production resspone to prices somewhat above border prices was quite elastic over time. Two factors appear to be important in determining supply response. First, a technology must be available at the farm level that provides a production function which makes supply highly elastic at existing producer prices. This has quite obviously not been the case in Jordan or Morocco even with relatively high producer prices. It has been the case in Tunisia with a comparatively low producer price. Quite clearly price policy can effectively influence supply only if farmers have the technological capacity to respond. Second, there must be the

institutional structure, in the broadest sense, which can support a production response to favorable prices. The institutional structure which could provide the research, information, agricultural inputs, market accessibility, etc. necessary to facilitate production response to prices was not in place for wheat farmers in either Jordan or Morocco. Neither goverment was prepared to accord the priority to wheat production needed to provide necessary institutional support. Adequate numbers of scientists were not trained, information was not effectively conveyed to farmers, an adequate system for distributing inputs, either public or private, was not in place, market systems were structured to handle imported grain not domestically produced grain, etc. Production functions based on utilization of improved technology could not be made operational in the context of an unfavorable institutional structure.

Analysis of experience in the four countries strongly suggests that a complex of policies need to be harmonized in support of efforts to increase agriculture production. It is a necesary but not sufficient condition that producer prices be competitive prices. A policy of subsidizing consumer prices may lead to market distortions or budgetary contraints which adversely impact on production. It appears highly likely that in both Jordan and Morocco stringencies imposed by the low consumer price policy led both governments to pursue a policy of reliance on wheat imports rather than attempt to support increased domestic production to more nearly satisfy demand. In both counties it is also evident that little priority was accourded to wheat production in country development plans. This meant that the necessary resources were not allocated which might have made possible a supply response to a favorable price structure. Precise definition of production problems, by different areas, and their solutions were not seriously addressed. By contrast, in Turkey a favorable producers price policy was supported by policies directed towards eliminating or mimimizing wheat imports and according high priority in support of efforts to increase wheat production. And in Tunisia, even with a consumer oriented price policy which generally kept producer prices relatively low, other government policies supporting a goal of achieving self sufficiency in wheat production made possible the utilization by farmers of a technology which made production increases profitable at existing prices. Thus it appears that, at least in the countries under consideration, that effective government support of increased production existed only when there was a coordinated bundle of policies that, on balance, made increasing output attractive to farmers.

C. Risk

In attempting to manage risk in a way that avoids losses which could destroy family security, the dryland wheat farmers

have recourse to a number of options. These include land fragmentation which disperses land farmed so as to reduce risks associated with natural disasters; allocating some family labor to off farm employment; producing a mix of crops and livestock to obtain maximum utilization of all plant growth; minimizing production costs by operating on low input production functions and expanding and contracting area planted as annual rainfall varies. All of these influence farmers willingness to adopt new practices. The projects were launched in the face of very long trends of ingrained farming techniques with not much analysis of risks, costs and returns to doing things differently.

The way in which these practices may affect farmers decisions on weed control illustrates the matter. Weeds have traditionally provided a substantial portion of animal feed in the dryland farming areas under consideration. Sources of weeds are those that grow with the wheat crop, those that grow during fallow and the early growth before spring or summer plowing. Only hand weeding of wheat fields requires any significant amount of labor with alternate employment opportunities in utilizing weeds for animal feed. The cultural practices introduced as part of the improved technologies includes the control of moisture and nutrient by chemical spraying of wheat fields, clean summer fallow and/or early plowing. The data available from two countries shows that substantial numbers of farmers adopt the use of herbicides to control weed in wheat fields but few farmers adopt early planting or clean summer fallow. Viewed from the perspective of a resource allocating farm manager striving to maxamize family security and minimize risk, the possible reason for the different responses of farmers to the improved practices may be as follows. By using chemical sprays to control weeds the farmer does increase the amount of grain and straw available for harvest. In addition, the labor not needed for weeding can be allocated to other income producing tasks such as off farm employment. The situation with respect to early plowing or summer fallow is quite different. True, moisture conserved from these practices will increase the size of the harvest. But, the unavailability of weeds for animal feed will reduce the value of the animals or increase the cost of feeding and no labor is made available for employment in alternate income earning activities. In fact it may be necessary to allocate additional labor to secure an adequate supply of feed. The adoption rate for new technology is partially determined by the way adoption of any particular practice affects the farm manager's decisions on resource allocation to maximize family well-being.

The available evidence indicates a strong relationship between adoption of new technology and the risks associated with the probability of insufficient rainfall. The reason for

this is the probable consequence of variability in rainfall rather than differences in the normal rainfall expected in various rainbelts. Of course, there is a lower limit of rainfall where wheat production is impracticable under any circumstances. Rainfall variability is much more important in lower rainfall zones than in higher rainfall zones because variations from the normal are apt to occur more frequently in the drier rainbelts and the consequences of receiving less rainfall than normal are more adverse in these zones. Two other factors are important. First, some improved technologies require greater amounts of moisture than the traditional technologies; high yielding variety seeds and fertilizer are cases in point. Second, because of higher input costs the risks of loss with adverse weather conditions are likely to be greater with many of the improved tecnologies than with the traditional low input production function.

Based on experience under the four projects there is quite probably a normal annual rainfall level below which the risks associated with the introduction of currently known technologies may be too great to justify either public or private investment. Taking into consideration diferences in temperature extremes and in soil quality, the cut off point probably is somewhere between 300 and 350mm of rain. The successful Tunisia program was in a wheat growing area where three-quarters of the land normally receives more than 400mm of rain per annum. In Turkey the normal rainfall ranged between 315 and 615mm.

D. The Cereals/Livestock Relationship.

Farmers, including dryland wheat farmers, attempt to maximize earnings from the total farm operation not each seperate crop. Most dryland farmers include animals, usually sheep, as part of a dryland farm management unit in the Middle East and North Africa. In making decisions about adopting new technology for wheat production the farm manager must consider the effect on returns from sheep as well as wheat or other crops. The role of weeds in this has been discussed above. In addition, wheat straw is utilized as an important component of animal feed. Because of this the wheat straw has a value; often the value of wheat straw is equal to that of the grain produced. The effect of new technology on the quantity of straw available ought to be taken into account in making decisions about anticipated returns. However, because, for the most part, the projects in all four countries excluded consideration of the role of sheep, the value of straw was ignored. This meant that such economic and agronomic assessments or analyses of returns or yield increases that were made underestimated returns to technology. This certainly limited the ability of agriculture technicians to convey to farmers the real benefits from using improved technology. It may also have led to rejection by technicians of alternatives

that were viable if the value of straw as animal feed had been taken into account but were not if only grain produced was considered.

E. Social and Economic Change.

In this analysis of the effect of social and economic change the three items discussed separately in the findings section will be treated together. All three of the elements are interelated and these interrelationships are illustrated more clearly by looking at the combined effects of them.

Increased alternative employment opportunities appear to be the key to the economic and social changes that have occured since the wheat projects were initiated. It is the real or perceived opportunity to increase family income by working in urban areas or abroad that leads to a flow of labor out of farming. As this occurs at least three things happen; farm labor becomes scarcer and the opportunity cost of farm labor increases, the market demand for wheat increases and the importance of risk associated with dryland wheat farming to family security decreases. The increasing scarcity and cost of labor when combined with land ownership fragmentation resulting from inheritance patterns brings about some predictable results.

First, the wheat market becomes increasingly monetized and broadened. This happens because the numbers of on farm consumers are reduced and former farm labor now earning an income in urban areas enters the market as consumers.

Second, the monetary resources available to the farm family will increase because of the increased monetization of wheat consumption and the remittances sent home from urban areas and abroad.

Third, with the oportunity cost of labor increasing, employment of labor resources on the farm becomes less attractive, unless it is possible to increase returns to labor by increasing productivity or product prices.

Fourth, as land owned becomes increasingly fragmented returns to the owner's family labor are likely to be reduced due to disguised underemployment.

Fifth, substituting capital for labor or utilizing land in alternate ways become economically more attractive as ways of increasing returns to labor on or off of the farm. Aditionally, this may well be the "technologically" best way to farm.

However, increased investment in capital equipment to increase labor productivity may not be a feasible alternative if land is scarce. In this situation the farm decision maker has, potentially, several options that may be pursued; if the technology is available he can invest in yield increasing, per unit cost decreasing methods of production, he can shift to producing a higher value product or a product which requires less labor input, he can increase his land by purchase or

renting land, he can rent machinery through a contract hire process, or he can rent his land to others and employ available labor off the farm.

Farmers in the four countries have in many instances selected one or more of these alternatives. Certainly in both Turkey and Tunisia farmers operating a substantial portion of dryland wheat farmland have utilized improved technologies to increase returns to labor. In Tunisia, at least, use of the improved technologies is directly asssociated with renting land to increase the size of farm and with tractor hire. In Turkey renting land to acquire larger holdings is also prevalent though its degree of association with adoption of improved practices has not been analyzed. Renting land to increase farm size is increasing in frequency in Jordan and custom hire for machine cultivation and harvesting is becomming widespread among dryland wheat farmers. The evidence does not indicate that either of these two practices have been positively associated with the adoption of improved technology, though some of the larger farm operators are known to be using many of the improved cultural practices recommended. The evidence does indicate that adoption of moisture conserving improved practices has probably been impeded because custom operators have not been willing to shift to using the appropriate technology. It also appears that custom operators in their attempt to maximize profits follow practices which decrease rather than increase moisture retention by the soil. In Morocco land rental appears to be less prevalent than in the other countries. However, there is evidence that farm operators are shifting production to products other than wheat. This practice also appears to be growing in Jordan. It includes such things as switching to higher value crops or getting out of cropping and shifting to raising sheep on land left to produce weeds. In both Jordan and Morocco use of improved technology appears to be associated with large farm operations rather than with small farms. Whether the options chosen by farmers are ones which lead to increases in yields and total output of wheat depends on the relative returns from the various alternatives. The increasing opportunity costs of labor appear to have made adoption of the new technologies at least partially dependent on the size of farm operation and the opportunity to command capital resources.

VI Conclusions And Lessons Learned

The projects undertaken in all four countries were narrowly conceived, focusing on technology transfer for dryland wheat production. Project success was not related to the kind of technology transferred. There were two factors which appear to have been clearly associated with the degree of project success in both increasing production and building institutions. The two factors were length of the time period during which external assistance was provided to the project and the amount of annual rainfall in the area of project implementation. It also appears that there is a considerable degree of intercorrelation between increasing production and institution building.

It is important to emphasize that there were some beneficial results in all four countries even though institution building and production objectives were not approached in two countries. It is not at all certain that, given existing circumstances, more could reasonably have been expected to be achieved in Morocco and Jordan. In both countries factors external to the dryland cereals sub-sector probably exerted negative influences that could not have been overcome. Government policies were, on balance, not supportive of increased wheat production. Development priorities limited both public and private investments in dryland agriculture and, in one country, security problems were a deterent during project implementation. In both countries maintenance of large consumer subsidies appear to have caused governments to favor satisfying consumer demand largely by wheat imports rather than through increased domestic production. There is little reason to believe that introduction of different technologies in any of the countries would have led to a greater degree of success in achieving project objectives.

A common characteristic of all four projects at the time of implementation was the little attention given to economic or social issues. For most of the projects this continued to a greater or lesser degree throunh the period of project implementation. The one exception is the Turkey project where increasing attention was given to economic issues as the project progressed. As a consequence it is not possible to reach reasonable generalizations on the influence of most economic and social factors.

Lessons learned from these projects which should provide guidance for future activities to increase wheat production in winter rainfall, dryland farming areas appear to be the following.

A. Producer price policy by itself is unlikely to bring forth positive production responses from dryland cereal producers. The entire policy package must, on balance, be supportive of price policy initiatives. What is important is the relation of producer prices to per unit costs of

production. There must be available at the farm level an acceptable package of technology that makes it possible for farmers to move from a low input traditional technology to a more responsive production function.

B. The risk factor is important and means of managing risks associated with the introduction of new technology appear essential. Risk is inversely correlated with the annual level of normal rainfall and directly related to the annual variation in rainfall. Thus, the higher the normal annual rainfall and the lower the variability in annual rainfall the less is risk management likely to be a deterent to introduction of new technology. In making decisions about adoption of new technologies farmers calculate the probabilities of success or failure. Proposed new technological packages have a greater chance of being adopted if the package includes tools for managing risk.

C. A proposed package of practices is unlikely to be adopted in its entirety by farmers. Rather improved practices are likely to be adopted one at a time or in small sub-groups of practices which are interrelated. Technology packages should be structured so as to facilitate adoption of practices which individually or in groups can have a meaningful positive effect on yields.

D. While projects may quite legitimately have the objective of increasing output for one crop or animal, it is extremely important to consider the affect of proposed changes in farming practices on the entire farm operation. Within this context, it appears to be essential to give full consideration to the relationship between crop and livestock production. The evidence is reasonably clear that in all four countries the rate of adoption of certain proposed practices was adversely affected because of the consequences for animal production. This does not suggest that a project needs to address the entire farm operation. It does strongly indicate that adoption of practices can be accelerated if production requirements for the entire farm operation are taken into account.

E. The successful adoption of new technology which will be effective over time by a wide spectrum of farmers is in large part dependent on the existence of an adequately functioning support system. This means that the necessasry research and information functions must be institutionalized so they can identify and deal successfully with a continuous stream of physical, technological, social and economic problems and opportunities. It is also essential that effective input supply systems be operating that are capable of providing the technologically most effective supplies and equipment in a timely manner.

F. Project objectives must be consistent with country priorities. Absent this consistency, it is unlikely that resources necessary to achieve project objectives and to

continue necessary activities will be made available or that appropriate policies and institutions will be developed and maintained.

G. Projects need to take into account to the extent possible the kinds of changes within and outside of agriculture that are likely to affect project progress. In all countries changes over time in labor costs and land tenure patterns had an effect on technology adoption. As it is impossible for all of the potential changes to be taken into account, projects should incorporate the necessary flexibility to ajust to external changes during the implementation period.

ANNEX

I. State of the Art and New Technological Innovations Under Development for Dryland Areas with Emphasis on Cereals

1. Variety Improvement

Over the past thirty years, considerable improvement has been made in the yield potential of cereals, particularly bread wheat. A major increase in potential for wheat resulted from the introduction of stiff, short straw, that is resistant to lodging, derived from a semi-dwarf gene obtained from the Norin 10 wheat line discovered in Japan. This has also been incorporated into durum wheats. This permits greater response to high fertility and favorable moisture in the yield of wheat grown under irrigation and in high potential dryland areas.

Other major improvements have been the composite result of the discovery and use of genetic characteristics for resistance to pests, primarily diseases, and a range of other yield-improving characteristics such as tolerance of soil toxicity factors, earlier maturity to reduce drought risk, etc.

The largest and most sustained research effort has been devoted to bread wheats and thus they have shown the greatest improvement. Because barley and durum wheats are more important in much of the Near East region, the more recent increases in research effort directed toward these two crops is of considerable importance. New varieties with much higher yield potential, and pest resistance have been, or are soon to be released for both crops. Breeding material still in the nursery stage of development show excellent promise for the future. Only limited improvement has occured in pulse legumes, but research is being intensified by ICARDA and ICRISAT. In addition, AID's S&T Bureau is supporting significant research under the Bean and Cowpea CRSP. Improvement in tree, vine, vegetable and oil seed crops has been limited to testing introductions primarily originating from private sector breeders in Europe and North America.

In the near term, advances in cereal yield potential can be expected from research utilizing crosses between spring and winter type wheat and barley in order to increase their gene pools, and through use of computer technology that makes it possible to keep track of a greater number of genetic characteristics in a much larger breeding population than was possible in the past. With ready availability, decreasing cost and increasing capacity of small computers, this technology should be incorporated into cereal breeding programs as rapidly as the necessary training and equipment can be made available.

Use of both genetic and chemical means of producing male sterility can greatly facilitate the number of crosses that plant breeders can make in self pollinated crops such as cereals. This, along with computer data management, can greatly enhance the total output of crop breeding programs.

On the longer term, advances in genetic engineering should permit the transfer of pest resistance, nitrogen fixation capability, and various additional desirable agronomic characteristics from other plant sources into the gene pool of each crop. So far breeders have been limited to close interspecific crosses such as between wheat and rye, but this should change with the emerging potentials of high technology. The wheat-rye interspecific cross has been widely used in an effort to develop a new cereal that has been designated as triticales. Although triticales has many desirable characteristics, the grain quality has not found ready acceptance as a human food, but is finding limited uses as a livestock feed. Work on this new cereal is continuing, but with less effort than initially.

In the past, resistance to most diseases has been based on single gene resistance factors. Because pathogens tend to mutate rather rapidly, resistant strains of pathogens that overcome the genetic resistance tend to develop and multiply soon after extensive planting of a new resistant variety. This has led plant breeders, in close collaboration with plant pathologists, to continually search the genetic pool of each crop for new sources of resistance to replace those which have broken down due to new strains of pathogens. Increased effort has been focussed on "horizontal" or multi-gene resistance, there is adequate evidence that use of the maximum number possible of different genes that produce resistance to a disease organism reduces the likelihood the organism can readily overcome the resistance through mutations. Utilizing single gene resistance, cereal varieties have had to be changed every 6-10 years. If multi-factor resistance is incorporated into future varieties, then long term resistance may be possible. Various techniques are under development for this purpose. Genetic engineering eventually will enhance this approach by opening up the gene pool.

Considerable money has been invested, particularly by the private sector, in research on producing hybrid wheat. The hope has been that increased yield potential, similar to that found in sorghum and maize, could be developed. The cereals are naturally self pollinating and thus each variety or individual plant is equivalent to an inbred maize line. Although considerable effort has been devoted toward finding specific crosses that would produce progeny with hybred vigor, large advantages that would justify the much higher cost of hybred seed have not come forth from research so far. As a

result, research on hybrid cereals is declining. If commercially viable discoveries are made in the future, genetic and chemical male sterility potential can make commerical hybrid seed production possible like with sorghum.

Because the IARC's particularly CIMMYT and ICARDA are primary centers of genetic and breeding research on cereals, they should be closely tied into backstopping USAID Mission cereal projects with training, research networking and visitations in order to insure use of the latest technology useful at the country level. In addition to cereals, ICRISAT, ICARDA, IITA, CIAT and other IARC's are working on comparable variety development in the pulse legumes of interest as rotation crops in the dryland areas of the Near East. Work on forage legumes appropriate for the area is being conducted by ICARDA. None of the IARC's work on tree crops or oilseeds used in Near East drylands. The U.S. universities, private seed companies, and high technology industries are in the forefront of the more basic type research that on the longer term should have major impact on variety improvement. It is therefore important that the IARC's be closely linked to this U.S. scientific capacity to insure minimum lag between discovery and use in international crop improvement. It is important for the AID Bureau for Science and Technology to insure adequacy of these links.

2. Improved Seed:

(1) Seed treatment

Many of the soil born diseases are readily controlled by use of seed treatment. For many years, mercury based seed treatment has been widely used, particularly by commercial farmers throughout the world. The treatment is simple and inexpensive. The major drawback has been the high toxity from mercury poisoning if treated seed is consumed. This has led to adding colored dye to the treatment to warn against eating or feeding treated seed. A variety of newer compounds without this high level of toxity are either available or are under development. All of these are more expensive. Research on systemic fungicides may lead to seed treatments that can control diseases other than the soil born complex now controlled. Such improvements may more than offset the higher cost over treatment with mercury compounds.

(2) Seed multiplication, certification and distribution

Although most countries in the Near East have some type of seed production system for multiplication and distribution, in most cases it can not efficiently handle the needs of a modern system of variety development-- increase under high quality control to maintain genetic purity, and distribution of seed of known genetic purity, quality, and germination to growers.

3. Soil Fertility

Use of fertilizer becomes an important means of increasing yields once constraints such as lack of adequate moistures are removed and the level of one or more of the required nutrient available in the soil becomes the limiting factor to increased yield. Because many of the soils in the dryland areas of the Near East are calcareous in nature, inadequacy of available phospherous is a common problem. These soils tend to adsorb the phosphorous in the soil and make it unavailable for use by plants. Unless very high rates of phosphorous fertilizer are used when broadcast and incorporated into the soil, it will be rapidly adsorbed by the soil to the extent that very little of the phosphorous fertilizer applied will be available for plant use. The best means of overcoming this problem so far developed is to band a concentrated amount of the fertilizer with or in close proximity to the seed. This gives a concentration that easily saturates the capacity of immediately surrounding soil to adsorb any more phosphorous and thus most of the applied fertilizer is available for the plants whose roots are in close proximity to the fertilizer from germination to maturity. This requires use of proper seeding equipment with fertilizer placement capability. This means a departure from the long traditional method of broadcasting seed by hand and discing them into the soil. Fertilizer has been used by the same method at seeding and is satisfactory for nitrogen or potassium, but very inefficient as explained in the case of phosphorous.

The level of soil nitrogen is generally insufficient for optimum growth except for legume crops or where legume crops that have had a high nitrogen fixation rate preceeded the sowing of cereals. Because nitrogen is very stimulative of plant growth and tends to increase the amount of water required to mature a unit of grain yield, it is highly important to be able to relate nitrogen application to amount of soil moisture available in the case of cereal crops. Over use of nitrogen fertilizer can result in yield reductions under conditions of moisture deficiency. The greater plant growth stimulated by the nitrogen fertilizer results in greater use of available soil moisture. If moisture is inadequate to mature the level of potential grain yield stimulated by the increased plant growth caused by added nitrogen, then the soil moisture will be exhausted before grain can be set or else mature. The end result may be either failure to set grain or shrivelling of the grain before maturity. Under these conditions of moisture deficiency, non fertilized cereals may produce a limited yield of grain where fields fertilized have a crop failure. The safest procedure is to apply only the amount of nitrogen required to produce

the desired level of early plant growth. A second application can be made before the end of the rainy season in late winter based on the level of accumulted soil moisture available. This may not always work in areas of highly variable rainfall due to lack of adequate rainfall after the top dressing to carry the fertilizer into the root zone. One alternative is to band nitrogen into the root zone with a chisel or other sub-surface applicator. The most efficient equipment and planting methods for this purpose are still in the developmental stage.

As yields are increased, close monitoring of other nutrients, particularly potassium, sulfur and other minor elements becomes increasingly important as they are removed by higher yields of cereal and pulse, grain and straw. This is particularly true of the Near East where the straw is also usually removed from the field and fed to livestock.

In order to provide the most appropriate fertilier recommendations for each crop requires an effective soils laboratory and soil fertility research program that can determine the response curves to the various nutrients in major soil types at various moisture levels and use this to analyse soil samples and make recommendations from these analyses.

The fertility requirements of pulse and forage legumes is much different than for cereals and other grasses because they fix at least part of their nitrogen requirement if properly innoculated. The requirements for tree, vegetable and other rotation crops are crop specific and require special research to optimize yield. The site specific nature of fertilizer responses makes this type of research more expensive because of the large number of crops involved. Increasingly, leaf analysis can be an important tool for monitoring the nutritional needs, particularly for perennial tree and vine crops

4. Innoculation of legumes

The ability of legumes to fix atmospheric nitrogen for plant use through a symbiotic relationships with nitrifying bacteria housed in nodules on the legume roots is of major importance in agriculture, especially in the Near East. Much of the dryland agriculture of this region utilizes either pulse or forage legumes in rotations with cereals as part of the cropping system. The mo t common pulse legumes are chick pea, lentils and mung beans. Vetches, winter field peas, and medics are the most common dryland forage legumes. Where these legumes have been grown for some years, the nitrifying bacteria are usually present in the soil and will result in legume innoculation. Because the dry summers and high soil ph tend to be adverse to long term survival of these bacteria,

inadequate innoculation from residual bacteria is frequent. In recent years, increased research has been devoted to the nitrifying efficiency of different bacteria strains. They have wide ranges in nitrogen yield potential, much like grain yield potential in plants. Therefore, it is important for research on legume production to include the most efficient innoculus strains. The USDA and various American univesities have ongoing research and provide samples of improved strains under AID funding. It is important to utilize these as well as sources in other countries such as Australia with major research on biological nitrogen fixation.

5. Weed Control

Competition for the limited water available under dryland agricultural conditions make weeds a more important factor than under less deficient conditions. Because water in most years becomes the primary limiting factor on crop producton, the available moisture will produce only so much plant dry matter. The amount of this dry matter that is in the form of weeds is a direct subtraction from the crops. Because the edible portion of many crops is the seed, this is the last portion of growth in the life cycle. If water is inadequate, then the seed becomes the most affected due to its life sequence in the growth process. Therefore, control of weed growth is one of the most dependable ways to increase crop production. Research in the Near East has shown weed control to be one of the innovations with the highest adoption rate.

Farmers in the region have always practiced some form of weed control. The most common has been through hand pulling or tillage. Traditionally, hand pulling has been favored because it permits feeding the weeds pulled up to the livestock. Although this practice may provide some often low quality supplemental feed for livestock, it is very inefficient from the desirable control of weeds. The farmers tend to let the weeds grow to nearly mature size before pulling in order to maximize the amount of livestock feed. This means the weeds have developed close to their maximum amount of dry matter and thus have used most of the water, nutrients and have often decreased light available to the crop. This danger in crop yield is partly offset by the feed value of the weeds. Measurements of this varies by weed species, but other practices in the farming system favor the seeding of weeds of low palatability or of poisonous nature to livestock which tends to minimize the salvage value of the weeds.

The most efficient alternative is the use of herbicides, such as 2,4-D for broadleaf type weeds and any one of several products for control of wild oats, all of which have been widely used in cereal growing areas throughout the world. These are standard practices with widely demonstrated high return on investment pay off in cereal crops. This has included significant levels of use in many Near East countries.

Herbicides such as 2,4-D have been widely used for about 35 years. It is only very recently that much more effective compounds have been discovered. Currently, various alternative products are under development, or early commercialization, that have superior qualities. Because repeated use of a single herbicide may cause build up of weed species resistant to this particular compound, it is important to have a range of alternatives because the species resistant tend to differ for each herbicide.

In addition to the selective control of annual seedling weeds, most Near East field have one or more deep rooted perennial weeds, some of which can completely smuther non-cultivated crops. These require special control techniques for each perennial species. Many new herbicides are becoming available that can kill these deep rooted perennials without sterilizing the soil with long residual chemicals as required in the past.

Although some of the most dramatic improvements in chemical weed control recently involve selective weeding of cereals, steady improvements are underway in selective weed control for most other crops. The number of weeds and crops involved and the high pay off from improved weed control justify greater research effort on modern weed science than is currently underway in most countries. Much of this is due to lack of research scientists trained in this discipline and knowledgable in what can be done. Correcting these deficiencies should receive high priority.

6. Improved summer fallow

The practices discussed previously involve only relatively minor changes in the current system of farming. Most of the dryland agricultural areas in the Near East utilize a crop-fallow system in which part of the land is "rested" from cropping every other year or every third year depending on rainfall. Unlike the fallow practices used in the more advanced agricultural dryland areas of the U.S.A. and Australia, the Near East system involves leaving the land neither tilled nor planted with a legume cover crop. Thus the fallow land grows up to weeds which are grazed off by livestock. As a result the system has been often termed "weedy fallow." Changing the system requires more than a simple technology change as it is a long traditional practice that is part of the livestock management system as well as for cropping.

From the standpoint of the basic purposes for leaving land fallow as part of the crop rotation in dryland areas, the weedy fallow system is inefficient in most regards. The primary functions of fallow are to conserve moisture so that crops have more than the precipitation from the current crop season to draw upon. In addition, it provides a chance for

organic water from crop roots and surface residue to break down and release nutrients, allows nitrifying bacteria in the soil to fix atmospheric nitrogen for crop use and breaks the cycle of crops to reduce diseases and insect pests that build up under continuos cropping. The same is true under clean tilled fallow for weeds where they are killed by cultivation and not permitted to seed. This periodic tillage is particularly helpful in killing or reducing the vigor of perennial weeds if they are regularly cut at intervals through the fallow period. The weeds use food reserves stored in the roots to produce more growth. When this growth reaches the stage that leaf area is sufficient to start replacing the nutrients used from the root reserve, then the tops are cut off by tillage. During a season, constant regrowth dependent on nutrient reserves in the roots will cause either death or severe weakness due to depletion of stored reserves in the roots.

In much of the U.S., fallow is kept tilled during the growing season. In addition to maximizing the various desired effects outlined, when properly done, substantial amounts of recipitation saved during the fallow year can have the same effect as increased rainfall. This requires keeping down all weed growth that utilizes soil moisture and keeping a dry dust mulch of soil on the surface to break the loss of soil moisture through natural capillary actions that permits water to move to the soil surface and evaporate.

The clean fallow system, even though widely demonstrated to have potential advantages over weedy fallow has not been widely adopted in the Near East. This may be partly due to tradition, and lack of adequate data on economic benefits, but is more strongly rooted in the need for the weeds as livestock feed at a crucial period of void in the livestock feeding cycle. This is true even though natural weed growth tends to be low in both quantity and quality in relation to forage crop alternatives. Because sheep and goats eat the more palatable weeds first, they are prevented from seeding. Those of the lowest desirability or with poisonous characteristics for the animals end up being left to produce seed. Thus a high proportion of the least desirable weeds is perpetuated by the system. The alternative requires replacement of these weeds by some other substitute source of feed.

Because of the importance of sheep in these agricultural systems, the Australians have tended to favor sowing annual type legumes, particularly medic or subterranean clover with the cereal crops. This produces enough legume seed to provide a predominantly legume stand in the untilled fallow year. Weeds are largely prevented from seeding by mowing after the sheep have grazed off the highly nutritious legumes. These legumes seed near ground level or bury their seed in the ground similar to peanuts and thus produce the seed that will grow with the cereal to repeat the cycle. This systems breaks

the crop cycle for pest and disease control, provides added nitrogen fixed by the legume symbiosis with bacteria and produces a larger feed resource of superior quality for livestock. It does not, however, provide moisture storage of fallow year rainfall. This system has been demonstrated widely in the Near East and is being adopted on a limited basis.

An alternative system is to grow a certain amount of a cereal/legume fodder crop to cover the livestock feed needs eliminated by conversion to clean fallow. This has most frequently involved sowing oats and vetch or barley and vetch. This system has also been demonstrated and is being adopted in some areas. It produces much higher quantity and quality of feed per unit area than weedy fallow.

There is need for considerably more research on various alternatives in order to determine the most cost-effective system that maximizes the benefits of fallow and fills the livestock needs.

The research direction on summer fallow has tended to differ between Australian and the U.S. where most of this work has been conducted. Because of the importance of small ruminants in Australia, the work has emphasized converting fallow to annual cropping using legumes to substitute for fallow. This work has focussed both on introduction of new legumes through plant exploration, and improvement of legumes through plant breeding. In addition, improvement in nitrification by legumes has received considerable attention through identification and culture of improved strains of innoculum.

The annual cropping research by ICARDA is directed more toward use of forage legumes for hay such as vetches grown with reduced seeding rates of oats or barley or winter field peas. This contrasts with the emphasis on grazing type legumes in Australia. Both of these offer potential improvements over the current weedy fallow that is standard in the Near East.

In the U.S., research in the past has emphasized use of low cost tillage methods that provide minimum soil disturbance, leave most crop residues on the surface as erosion protection, yet break the capillary canals in the soil to stop movement of moisture to the surface. Because sheep and goats are not part of the dryland farming system in the U.S., the emphasis has been on moisture conservation and prevention of soil erosion. Keeping large amounts of straw resides on the surface has been useful for both purposes. The surface mulch from staw reduces surface soil temperature in the summer, thus reducing soil moisture loss and prevents both wind and water erosion. Because of the high value of straw as animal feed, this is not currently applicable to the Near East. The shallow tillage methods are, however, both applicable and desirable because of lower cost and improved erosion control.

Current U.S. research is heavily directed toward zero or minimum tillage fallow. Since weeds can be cheaply controlled by the new highly active broad spectrum herbicides that do not leave toxic soil residues, this can substitute for tillage. It leaves the maximum crop residue on the surface and the lack of any soil disturbance provides high resistance to wind and water erosion. The lack of break in capillary tubes in the soil causes more water loss in the heavier clay soils, but losses are usually less than the conventional stubble mulch tilled fallow on loam and sandy soils. One method of breaking this capillarity in heavier soils under test is use of a sub surface blade that does not disturb the soil surface but causes a subsurface break in the soil structure.

The primary difficulty with zero tillage has been to find seeders that will seed through the heavy straw residue and place seed deep enough in the untilled soil without clogging or overly high power requirement. The desired level of equipment performance has not yet been attained except with very large and expensive machines. Because increasing farmer use of this method is ocurring, the effort on equipment research to solve these problems is increasing rapidly.

Another problem with this system which is often called "chemical fallow" is that seedlings of cereals seem to be slower in establishing adequate root systems and lack early vigor compared with traditional tillage. The causes are being investigated and appear to be due to either biochemical or microorganism inhibitor associated with non-tillage. Final yields do not seem to be affected by the seedling problem in most cases.

Tillage tends to be a factor in control of certain insect and disease pests. Zero tillage eliminates these benefits. The importance of these factors will vary according to pest problems and research to date has indicated more the potential for problems under certain conditions than as a universal problem.

The importance of this U.S. research for potential applicability should be followed by research programs in the Near East, but is not yet a technology for major effort toward technology transfer.

7. Seeding

Most of the cereals in the Near East are hand broadcast after fall rains have started and are covered either by discing into the soil with a cover crop disc or if already plowed by means of a harrow. Seeding rates used in this broadcast seeding system tend to be at least 50% or more higher than when grain drills are used. One advantage of the traditional system includes the ease with which tillage can be deferred until

adequate rain to minimize power requirement. The seed can be incorporated as part of the primary tillage operation. In addition, the seeds are buried at various depths and thus if those near the surface that germinate first under the influence of initial rains should die from drought where initial rains are not sustained by continued precipitation, then a seed reserve at deeper levels is already planted for later germination once additional moisture is received. Because yields from early germination are potentially greater, these can be capitalized on in years of adequate moisture without jeopardy to obtaining a smaller crop from later planting in years of less favorable early moisture. In addition without the benefits of herbicides, the dense stand and close spacing of cereal seedlings provides maximum competition to the weeds.

The advantages for use of modern grain drills are that lower rates of seed can be precision planted at a depth that will defer germination until adequate moisture has been received to give reasonable assurance of sustained growth, yet early enough in favorable years to provide the benefits of early seeding. Standard drills require prior seed bed preparation and thus are more adapted to mechanized farms with adequate power to prepare a timely seedbed regardless of soil moisture. They can utilize varied row spacing which may have some advantages in dry years as outlined later. The space between rows provides a good seed bed and environment for weeds, so adequate weed control becomes even more important with the use of drills. Because drills are usually part of introduction of modern technology, then fertilizer to take advantage of increased yield potential of improved varieties and weed control becomes important. The grain drill with fertilizer attachment is the best means of banding phosphorous next to the seed or placing it with the seed. The importance of phosphorous placement was covered in the section on fertilizer. There are a number of types of drills. These include single disc opener, double disk opener, shovel opener, chisel, etc. Special modifications for use with clean fallow that permit seeding into residual moisture known as deep farrow drills are an example of special purpose drills. The best drill type depends on soil type, various farming practices, stoniness, etc.

8. <u>Seeding rate and row spacing</u>

A lot of trials in the Near East and elsewhere have been devoted to seeding rate. In general, under hand broadcasting the seeding rate of 150-200 kilograms per hectare traditionally used in the region have proved to be about optimum. Under drilling, usually any advantage of rates beyond 60-90 kilograms per hectare are infrequent. Much less work has been done on row spacing. Work in the western U.S. has shown advantages under low moisture conditions for wider row spacing than commonly used by most conventional grain

drills. As a result, drill spacing used in the western U.S. drylands normally are set for wider row spacing. It has been found that in good years, yield does not decrease significantly with increasing the normal spacing between drill rows to double or more. In dry years this increased distance between rows favors higher yields because as moisture is depleted, the roots of the cereals reach out and tap the moisture in the soil between the more widely spaced rows. This response has been used for many years in other crops such as cotton. With cotton, there has been a practice of seeding two rows in close proximity in a bed and then leaving a major gap between beds. Recent work applying this to dryland cereals has shown promise and is worthy of further trials. The advantage is that the fertilizers, particularly phosphorous can be concentrated between the two closely spaced rows. The roots will initially concentrate in the fertilizer zone. As moisture is depleted, they will then reach out into the unplanted area between the next two row strip. This system can only be used with good weed control. The work has been with winter wheat which tends to tiller more profusely than current spring wheat types used in the Near East. The high tillering capacity provides a buffe against yield reduction during wet years as the plants produce more heads to utilize the abundant moisture. If this system proves to have consistent advantage in buffering the effects of drought, then it may require special variety development, perhaps built around current work on crosses between spring and winter cereal types.

9. Tillage Equipment and mechanization

Mechanized agriculture until more recently has been built around deep stirring of the soil to bury the sod when opening new land for agriculture and covering the crop residue from the previous crop on regularly tilled land. The two implements traditionally used for these purposes have been the mold board and disc plows. The European settlers in the Near East introduced both implements along with mechanical agriculture. Although each of these implements are used, the one way disc plow called a cover crop has been most widely used. It works well even in stoney ground and can till at various depths depending on how the discs are set. It does an acceptable job of covering all crop residue. The dissadvantages in comparison to more recently introduced implements used widely in the drylands of the U.S. and Australia are much greater power requirement, increased traction required that limits use under wet conditions, and a seed bed that has high water and wind erosion potential. This is particularly true for water erosion when used up and down slopes rather than on the contour. The end disk makes a trench that can easily be changed into a gully with heavy run off after a rain. Because most farms in the Near East have been sub-divided up and down slopes, the fields tend to be longer up the slope than across the slope making it more difficult or sometimes impossible to plow on the contour.

Because of these erosion factors, chisel and sweep type plows that till more shallow and leave much of the crop residue on the resultant rough surface have become almost universal in drylands of the U.S. They require much less power, leave a less erodible seed bed and require less time than the disc and mold board plows. Although it took a considerable educational effort to convince farmers they did not need the nice black seed bed based on tradition, the eventual acceptance in the U.S. and Australia has been very high. These advantages are perhaps even more important to the Near East. Proper use of these implements in relation to soil conditions needs to be refined for the major soil type in each Near East Country and the benefits and proper use demonstrated to farmers. Because of traditions and pride in deep tillage and a clean seed bed, farmers first tendancy is to try and use sweep and chisel plows for deep tillage to simulate the results of disc plows. This defeats the advantages and is unduly hard on the equipment.

Another implement widely used in industrial country dryland areas that practice clean fallow is the rod weeder. It controls weeds and keeps a surface dust mulch to reduce moisture loss. It works best in loam and sandy soils without rock outcroppings. This tends to limit its areas of usefulness in the Near East.

Rock pickers are receiving increased attention as labor becomes increasingly scarce in the Near East. Many dryland areas can not easily be mechanized for planting and harveting because of excessive stoniness. Various types of mechanized rock pickers are available. Experience to date indicates many of those imported are not sturdy enough to stand up under the conditions faced. Those that are succesful are expensive. The cost benefit ratios need much more detailed study.

Because of labor shortages and high costs, many of the dryland areas need maximum use of mechanized harvesting equipment such as combines, hay balers, etc. Equipment for harvesting some of the pulse legumes satisfactorily is not adequate in many cases. There is also increasing interest in mechanical harvesting equipment for tree, vine and vegetable crops. These needs, along with those already outlined under tillage eqiuipment and the increasing need for application equipment for herbicides and pesticides makes a comprehensive mechanization research program of increasing priority in most countries.

10. Pest Management

Modernization of agriculture increases the importance of pest and disease control. The weed control needs and use of breeding to increase pest and disease resistance has already been discussed. Because crops will continually be plagued by new or resurgent pest and disease outbreaks, comprehensive pest monitoring, forecasting and research capability on control measures became of prime importance. They should be fully taken into consideration from the very beginning of crop development programs. Most pests tend to be crop specific or more important in some crops than in others. As a result, significant resources are required where diversified cropping is involved.

Livestock Improvement

Other than draft animals, particularly donkeys and camels, the dominant livestock population in the dryland farming system in the Near East are sheep and goats. On most diversified farms, they represent either a significant or a dominant source of income. They also represent the capital savings of the farm and act as a hedge against unforseen needs as they have a ready market for quick acquisition of monetary resources when required.

In spite of their importance, the management of the farm small ruminant flocks is generally very deficient from the standpoint of maximum production and return. Aside from some long held cultural constraints almost impossible to overcome in the short run, such as reluctance to castrate lambs and kids, many changes are possible that can make significant improvements.

The flocks are scavengers and are dependant on grazing waste areas and crop residues. They may be provided supplemental feed for short periods of feed shortage or during the latter part of gestation and during lactation. Breeds indigenous to the region potentially have some of the highest reproductive rates anywhere. These are not adequately exploited due to lack of good nutrition during the breeding season to increase multiple birth potential and fill nutritonal needs during pregnancy and lactation to ensure healthy birth and growth. Inadequate control of internal and external parasites and various diseases contributes to slow growth and added mortality. The practice of slaughtering lambs and kids at 10 kilograms weight reduces meat production potential as this is the point at which they have rapid growth potential to 30-40 kilogram weight if given adequate supplemental feed and parasite control.

Overcoming these limitations requires both an educational effort and changes in the management of the nutritional resources or potential resources available.